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ABSTRACT

THIS SCHOOL DISTRICT UTILIZED THE GENERALIZED ACADEMIC SIMULATION PROGRAMS (GASP) TO ASSIST IN MAKING DECISIONS REGARDING THE KINDS OF FACILITIES THAT SHOULD BE CONSTRUCTED AT PILCHUCK SENIOR HIGH SCHOOL. MODULAR SCHEDULING WAS ONE OF THE BASIC EDUCATIONAL PARAMETERS USED IN DETERMINING THE NUMBER AND TYPE OF FACILITIES NEEDED. THE OBJECTIVES OF THIS STUDY WERE TO INVESTIGATE--(1) THE MAJOR QUESTIONS TO BE ANSWERED BEFORE SIMULATING THE PROGRAM WITH GASP, (2) THE QUALITY OF THE DECISIONS RELATED TO THE SPACE REQUIREMENTS, AND (3) THE ECONOMIES ACHIEVED BY USING GASP. A COMPARISON OF THE SPACE REQUIREMENTS GENERATED BY GASP AND BY AN ARCHITECTURAL FIRM INDICATED THAT HIGHER QUALITY DECISIONS WERE OBTAINED FROM GASP. (IC)

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BETTER SPACE CONSTRUCTION DECISIONS

BY

INSTRUCTIONAL PROGRAM SIMULATION

UTILIZING THE

GENERALIZED ACADEMIC SIMULATION PROGRAMS

A study jointly undertaken by the Marysville School District and the
Research Section and Educational Data Processing Center
of the Office of the State Superintendent of Public Instruction
Olympia, Washington

by

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PROBLEM

School districts faced with construction of secondary schools to house a modular schedule are faced with the task of making decisions based on inadequate information. Little information is available which will assist a school district in making these decisions. Further, present methods of information gathering, based upon present programs or best guesses about the new program, sometimes err by letting traditional values influence interpretation.

In view of this, school districts sometimes play it safe by constructing either completely or partially traditional classrooms. This leads to only partial realization of the benefits of the modular schedule through the use of large and small group instruction and independent learning centers.

Thus, inflexible and inefficient school plants are constructed to house programs based upon a modular schedule. This results in wasted space, high remodeling cost, and less than full implementation of the innovative opportunities inherent in the philosophy underlying the modular schedule. With the computer program GASP III (Generalized Academic Simulation Program), it is possible to generate information that would allow much more accurate decisions regarding the kind of facilities to be constructed. In the process of preparing input information for such simulation, administrators are faced with the task of specifying in detail the envisioned program.

The Marysville School District was faced with such a problem when it undertook to plan and build Pilchuck Senior High School in 1966. Educational specifications were prepared which incorporated the modular philosophy.

As the Marysville architects translated the specifications into projected square feet, it became apparent that neither the district nor the architect had adequate information regarding the kind of building space required by the modular philosophy. The square feet of the specified building far exceeded state allocations and available district funds. The district was asked to cut approximately 80,000 square feet from these specifications. At this point, the Marysville District approached the State Department of Public Instruction and asked for help with a simulation project to determine what could be cut.

This study utilized GASP to assist in making better decisions regarding the kinds of facilities that should be constructed at Pilchuck Senior High School. It was undertaken in cooperation with the State Department of Public Instruction. Washington is the only state education office to date to have attempted simulation with GASP. Since state funds play a major role in all public school construction, this study demonstrated that considerable savings are possible using simulation. It is not unreasonable to expect that all districts contemplating a modular schedule be encouraged to simulate their program before construction is contemplated.

OBJECTIVES

The Stanford School Scheduling System program and the GASP program are designed to generate schedules that are being used in public schools. In 1967-68, four secondary schools in the State of Washington were operating on GASP generated schedules and one junior high on a Stanford generated schedule. Eleven additional public schools have expressed interest in GASP schedules for 1968-69.[1] Only one of these schools was constructed for a modular philosophy. Consequently, the other schools have had remodeling costs or restrictions placed on their programs because of inadequate or inappropriate facilities. It appears that if a school's program were simulated, substantial savings could be realized in terms of remodeling costs and inappropriate facilities initially constructed. In addition, fewer restrictions would be imposed upon the program of the school.

This study proposed to investigate the following questions:

1. For those schools considering building a school to house a modular schedule, what are the major prior questions that must be answered before simulating the program with GASP?

2. By providing GASP with the above information and the following parameters, will it generate information which will allow us to make better decisions concerning the kind of space requirements of such a modular program?

(a)	Student and teachers scheduled without conflict		85+%
(b)	Room utilization tolerances	Large Group Room	60+%
		Regular Classrooms	75+%
		Seminar Room	75+%
		Special Purpose Room and Labs	50+%

3. Are the economies achieved by using GASP significant?

RELATED RESEARCH

The use of computers to section/schedule students began in 1956 when James Blakesly of Purdue University developed a computer system "for registering, scheduling and assessing fees for all students as a management device directed toward the improvement in a student's choice of courses and the overall utilization of resources."[2] Since that time, M.I.T., the University of Rhode Island, and the University of Massachusetts have all developed similar programs. Purdue University is presently experimenting with the construction of a class schedule, but it is not, at this time, available to the public schools.

1 Discussion with Dr. Alan Metcalf, Director of Research, Office of the State Superintendent of Public Instruction, Olympia, Washington

2 Murphy, Judith: School Scheduling by Computer, "The Story of GASP," p. 39. Educational Facilities Laboratories, Inc., New York, June 1966

A number of computer programs are available which assign students to sections or classes. Generally speaking, these programs assume a fixed schedule of classes with times, rooms, and instructors assigned a schedule that has been built in the traditional way; by hand -- not computer.[3] Such sectioning programs can and do provide the administrator with valuable help in improving schedules since, with computer speed, several runs can be made utilizing varying schedules at relatively little cost.[4]

While sectioning work was going on, others were attempting to automate the generation of the master schedule. Dr. Albert Holzman of the University of Pittsburg concentrated on the building of a theoretical model, utilizing the linear-programing and heuristic approach to the generation of master schedules.[5] Additional research has been done on the use of computers in flexible schools of the future . . . at various centers, including System Development Corporation, Santa Monica, California, and the California State Department of Education's Center for Research and Development in Educational Data Processing at Sacramento.[6]

Out of this research has come Professor Robert Oakford's Stanford School Scheduling System and Robert Holz's Generalized Academic Simulation Program (GASP). Both of these are generalized programs for constructing master schedules and assigning students, and whatever their "algorithmic difference, the two programs evolved as similar in major practical respects."[7]

It is not known if the Stanford program has been utilized in simulation studies. It has been used by public schools in California, Nevada, Oregon and Washington for scheduling and sectioning. GASP has been used twice for simulation studies and a number of schools have used it for scheduling and sectioning.

In 1963, after working under an Educational Facilities Laboratory grant for two years, Robert Holz felt GASP to be sufficiently "debugged" to offer it to other institutions besides M.I.T. Three high schools, two of which were "Trump" schools, operated with GASP schedules in 1963-64: Wayland High School, Wayland, Massachusetts; Ridgewood High School, Norridge, Illinois; and Cohasset High School, Cohasset, Massachusetts. In 1964-65, a fourth school was added -- Pasack Hills High School, Montevale, New Jersey. The success of these schools with GASP schedules prompted the Educational Facilities Laboratory to drop GASP as an experimental scheduling project in 1965.[8]

The success of Ridgewood High School's experience with GASP demonstrated according to Principal Howard, that:

1. A schedule of great complexity . . . can be built by computer at less overall cost than if it were done by hand by an administrator.

2. The computer-built schedule has fewer conflicts than does the handmade schedule.

3 Ibid, p. 39
4 Ibid, p. 40
5 Ibid, p. 41
6 Ibid, p. 41
7 Ibid, p. 41
8 Ibid, p. 8-9

3. Class lists, room utilization lists, teacher schedules, and student schedules are extremely accurate. For a modular schedule, such lists are almost impossible to develop accurately by hand except at great cost in time and money.

4. The greatest advantage to the school of a computer-built modular schedule is that the scheduler, in the process of generating his master schedule, is able to construct a large number of preliminary schedules. He can analyze each and then incorporate improvements in each succeeding run until he reaches a satisfactory and workable combination of courses, time allocations, teachers, and rooms within the scope the school has indicated.[9]

In the State of Washington, Joel E. Ferris High School, Spokane; Selah High School, Selah; Interlake High School, Bellevue; and Glendale Junior High School, Seattle, all operated on GASP prepared schedules in 1968-69. This number may grow to twenty-six by 1969-70.[10]

In 1963, under Educational Facilities Laboratory financing, the administration of Meramec Junior College, a proposed junior college in St. Louis, utilized GASP's simulation capabilities. They attempted to simulate classroom utilization at 80% and laboratories at 65%. In other words, they proposed to operate their college with classroom utilization as efficient as secondary schools. The simulation results proved that such utilization percentages were quite feasible, and also indicated that they could meet all their program requirements and still reduce by 22 the number of classrooms they had projected. St. Louis is presently constructing two more junior college campuses utilizing the original GASP simulation. Dr. Cossand, president of the junior college district, predicts that the district may save upwards of $10 million in construction costs for the three campuses by applying the utilization rates for both room and seat space established in the Meramec study.[11]

The second simulation study utilizing GASP was carried on by Hewes, Holz and Willard, Inc., for Evanston Township High School, and was concluded in 1966. Evanston was a school of 3,500 students and needed to be expanded to accommodate 5,300 students by 1970, and 6,100 students by 1975. This study raised ten specific questions unique to Evanston's remodeling and construction needs and its school within a school concept. At the end of the study, answers were provided to the administration of Evanston on all ten questions which ranged from student traffic patterns to suggested space needs.[12]

As a result of Educational Facilities Laboratory's work with GASP, it has suggested certain ground rules. Their last is this --

> *"To exploit the advantages of GASP, schools should parlay the time and money they have put into computerizing the master schedule into: a) feasibility studies of contemplated changes in the school program; and b) studies to guide the design and size of contemplated additions or new plants."*[13]

9 Ibid, p. 11
10 Metcalf, op. cit.
11 Ibid, p. 31-33
12 Hewes, Holz, and Willard, Inc.: Simulation Study Report. Educational Facilities Laboratories, New York. August 1966.
13 Murphy, op. cit., p. 35

METHOD

Information required by the GASP program to generate schedules are time patterns, classes, instructors, students, and rooms.

Time Patterns

The following parameters were selected early in the study as being appropriate for the Pilchuck High School program. A five day cycle with 19 twenty-minute modules daily, with a total of 95 modules in a week. A ten minute administrative and attendance period was also planned daily. Lunches were set at 40 minutes in length to run in three consecutive waves. The following day combinations (Monday-Tuesday; Tuesday-Wednesday; Wednesday-Thursday; and Thursday-Friday) were removed as undesirable from the total GASP generated time patterns.

Classes

Late in 1966 and early in 1967 the basic curriculum for Pilchuck High School was prepared over a six month period by a study committee headed by the principal. Educational specifications were written, and reviewed again in September 1967, before simulation. At that time decisions were made to offer basically the same program as presently offered at Marysville High School, but to work toward a non-graded approach through a program which allows students to study courses not normally offered in the curriculum. In addition, efforts would be made to personalize and individualize instruction before markedly changing course offerings.

Each department at Marysville High School, after discussions with administrators of schools operating on modular schedules and after discussions in their own departments, determined the number of modules they desired per week for courses in their departments and how these modules would be distributed between large group, regular or laboratory groups, and seminar groups. Discussions with schools operating on modular schedules indicate that such determinations will change. However, we believe that such decisions would not significantly change space needs. What is important is that the teachers themselves made decisions concerning the amount of time they desired and the organization of that time.

Large group size was determined by using the total enrollment of a course. Regular classes and laboratories were varied from 24 to 30 students per instructor and seminar size from 8 to 15 students per instructor. These determinations were made after discussion with administrators of schools with modular programs and the principal's judgment and experience.

Enrollments for courses to be offered at Pilchuck High School were predicted by using the percentage of the total enrollment at Marysville High School enrolled during 1967-68 in the same courses. In using this method of prediction, it was assumed that no method of prediction could really estimate the likes and dislikes of students, and that present enrollment was a valid method.

Instructors

An instructional staff was generated by using as a guide the Washington State suggested minimum standard of 25 students per teacher at the high school level. More teachers than the standard indicated were used for the simulation. An instructional staff of

68 teachers and an administrative, counseling, and special services staff of 13 1/2 persons were used in the simulation. Area chairmen were assigned instruction time of 50 out of 95 modules per week and regular staff instruction time 60 out of 95 modules per week. These estimates were prepared using Lloyd Trump's suggestions and the program needs of Pilchuck High School. Additionally, several personnel at the new school would continue to be shared with other schools in the district and were thus assigned instructional modules accordingly. The several staff members that would function as teacher-counselors were also assigned adjusted instruction loads. These notes will aid in interpretation of the findings later in this report.

The instructional staff was assigned to classes using logical assignments insofar as possible. Thus, for example, an English teacher who had to teach in two departments would have a second assignment in Foreign Language, Humanities, or Art, rather than P.E. or Industrial Arts.

Teacher aides would be employed to supervise the resource centers. Thus, no teachers were assigned to these areas. These assignments could be made using the teacher's unscheduled time when school opened.

Students

Course enrollment percentage predictions were based upon the 1967-68 Marysville High School enrollment of 1,157. Since the actual 1967-68 enrollments fell short of the predicted 1,500 enrollment, mythical students were created with required subjects appropriate to their grade level, and then courses appropriate to grade levels were added randomly until the predicted enrollment of 1,500 had been attained. This may be considered an arbitrary way of arriving at mythical students; however, it is workable in the absence of other perhaps more suitable methods.

Rooms

The room needs and room utilization percentage of the envisioned program of Pilchuck High School, both at 1,500 and at 850, were of primary concern in the simulation. No room restrictions were placed on the initial simulation runs. Simulations with both 850 and 1,500 students were made with excessive classrooms initially and were reduced on subsequent runs until the predetermined utilization tolerances were achieved. These predetermined percentages were arrived at after discussions with schools now operating on GASP generated schedules.

The following list of classrooms was provided to the initial simulation run:

Rooms	1	400-seat Large Group Instruction
	1	200-seat Large Group Instruction
	28	15-seat Seminar Rooms
	31	30-seat Classrooms
	2	64-seat Science Labs
	1	60-seat Wood-Metal Lab
	1	30-seat Power Mechanics Lab
	1	30-seat Vo-Ag Lab
	1	30-seat Elect.-Electronics Lab
	1	30-seat Drafting Lab
	1	30-seat Art-Painting Lab

1	30-seat Crafts Lab
1	30-seat Graphic Arts Lab
1	30-seat Vocational Cooking Lecture Room
1	60-seat Home Economics Lab
1	15-seat Home Ec. Sem. - Library
4	30-seat Locker Room (Gym)
2	50-seat Typing Labs
1	25-seat Office Machines Lab
1	24-seat Distributive Education Lab
2	30-seat Business Ed. General Purpose Rooms
1	90-seat Band Room
1	90-seat Vocal Room
1	30-seat Ensemble Room
1	150-seat Instructional Materials Center
4	70-seat Resource Centers
1	45-seat Tape Retrieval and Listening Center
2	30-seat Special Education Rooms

FINDINGS

I. For those schools considering building a school to house a modular schedule, what are the major prior questions that must be answered before simulating the program?

As has been indicated previously, GASP requires five categories of information concerning: a) Time Patterns; b) Classes; c) Instructors; d) Student Course Selections; and e) Rooms. In addition to this information, the following is a list of questions that GASP simulation requires, and related questions the researcher found necessary and fundamental to answer prior to simulation:

A. Time

1. What length of module is desired? (15, 20, 25, 30, etc.)

2. How many modules per day? Per week?

3. What is the length of the cycle?

4. Are certain time structures desired? Certain combinations of days?

5. Will your selected time structures minimize time gaps?

6. Is a weekly convocation built into the schedule, or will each module be shortened on assembly days? How will student break, pep assembly, and student council be handled?

B. Classes

1. What courses will be offered?

2. How many minutes per week does each department desire?

3. Concerning individual courses and departments, how many modules of large group instruction will be needed per week? How many class meetings per week and for how long? How many sections per class? How many sections for regular classrooms, laboratories and seminars?

4. Will laboratories be open to students on independent study all the time? Part of the time? Never?

5. How many instructors per large groups?

6. How many lunch sections, for how long, and at what time of the day? How many students can be handled per lunch? In waves or separated by mods?

7. How many students per mod can be handled in independent study?

   a. Number of resource centers and size?

   b. Number of labs, open or closed?

   c. Number of instructional materials centers; size and resources available in each?

8. Are students of a particular large group, regular class, lab, or seminar to be kept together for each meeting session? (Tying)

9. Will instructors and students of large groups, regular classes, labs, and seminars be together for each of the sessions? (Threading)

10. Will specific times be designated for some classes to meet? Will GASP be allowed to select the best possible time?

11. Is ability group or track part of the plan? In large group? Regular class? Laboratory? Seminar?

C. Instructors and their assignments

1. On an average, how many students per teacher?

2. How many teachers will be needed? Teacher aides? Counselors? Administrators?

3. What will these teachers teach?

4. How many mods per week will they teach? How many mods of resource assignments? How many mods of conference time for planning and conferencing with students?

5. Are entire departments to be freed at one time?

6. Can all area chairmen or department chairmen have a common conference period at least once a week?

7. Will team teachers be unscheduled on large group presentation days and have common plan periods? How many times per week?

8. Is there to be a team leader in charge of every team?

D. Student Request

1. If simulating, from what source are student requests generated? Will the method used provide accurate predictions of future enrollment?

2. How many subjects will students be allowed take?

3. How will one semester classes be designated?

4. How many modules of independent study will students be allowed per day or week? Will it vary by grade level?

5. What will be the acceptable percentage of students scheduled without conflict?

E. Rooms

1. How many rooms are to have specific classes assigned?

2. What will be acceptable utilization percentages?

3. What is the seating capacity of each room?

4. Will classrooms and seminar rooms be available for any class or be assigned to specific areas?

F. Related Questions

1. Disregarding facility, is there a maximum large group size that should not be exceeded?

2. Will one man be assigned to every large group team?

3. Will teachers or aides supervise resource centers?

4. What percentage of the student body will be unable to accept independent study responsibilities? What provisions will be made for them?

5. Will all students automatically have independent study on day one? Will all be automatically excluded? How will selection be made for those in independent study?

6. Will there be levels of self-directed study?

7. Will halls be open or closed? (open - students can spend their independent time in the halls visiting; closed hall - students cannot)

8. Will the cafeteria be open for snacks all day? Part of the day? Not at all except for lunch? How about the student center? Will the cafeteria be used for any reason other than feeding? If so, is it designed properly?

9. For what number of students per mod will independent study space be provided?

10. Fundamentally, will student instruction be individualized, or will the emphasis be on efficient use of staff? Will one weigh more than the other, or will there be a compromise?

11. Will students be allowed to arrive late and leave early based upon their daily schedule?

12. Will most of the students be scheduled into classes the last several mods on Fridays?

13. Will teacher assignments vary based on experience level and extra responsibility load?

14. Perhaps the most important question - is the staff, student body, and facilities ready for a modular schedule?

    a. How long has there been teaming?

    b. For how long have teachers been able to decide how they will use blocks of instruction time?

    c. How long has the school operated on a modified schedule?

    d. How much experience have students had with independent study?

    e. How well does the principal and the staff understand the limitations of GASP and the modular schedule?

    f. Does th majority of the staff believe that most students are capable of self-direction?

    g. Have problems of attendance and student accounting under a modular schedule been anticipated?

    h. Are teachers prepared to utilize the seminar as a problem-solving and discussion period?

    i. Has the staff undergone sensitivity training?

15. What in-service education has been carried on thus far with the staff in regard to the modular philosophy? What strategies are planned?

16. How will the public be informed of the program?

17. How will the students be prepared for the modular philosophy?

18. Has the cost of computer and programmer time been considered by the district?

II. By providing GASP with the information from the preceding questions and within the following parameters, is it possible to generate information which will assist in making better decisions concerning the kind of space requirements of a modular program with 1,500 students as with 850?

(a) Students and teachers to be scheduled without conflict 85+%

(b) Room utilization tolerances

Large Group Rooms	60+%
Regular Classrooms	75+%
Seminar Rooms	75+%
Special Purpose Rooms or Laboratories	50+%

A. The initial input information for simulation at 1,500 and 850 has previously been described. The following are the results and interpretations of the simulation for 1,500 students.

1. Students scheduled without conflict 85%

While this percentage is too low as a final sectioning run, no attempt was made to freeze parts of the schedule and juggle times to arrive at a more acceptable conflict-free schedule. Only 15% of the student requests have been invalidly scheduled or scheduled in classes where that assignment conflicts with another assignment.

2. Teachers scheduled without conflict 99%

3. Time schedule evaluation 94%

Both of the above figures are acceptable, especially since no attempt was made to resolve the conflicts.

4. Rooms and their utilization:

Number	Room	Utilization at 1,500
1	400-seat Large Group Instruction	64%
1	200-seat Large Group Instruction	82%
16	15-seat Seminar	77%
9	30-seat Classroom	78%
2	64-seat Science Labs	56%
1	60-seat Wood-Metal Lab	64%
1	30-seat Power-Mech Lab	52%
1	30-seat Vo-Ag Lab	58%
1	30-seat Elect.-Electronics Lab	52%
1	30-seat Drafting Lab	76%
1	30-seat Graphic Arts Lab	76%

Number	Room	Utilization at 1,500
1	30-seat Art-Painting Lab	56%
1	30-seat Crafts Lab	52%
1	30-seat Voc. Cooking Room	28%
1	60-seat Home Economics Lab	52%
1	15-seat Home Ec. Sem.	80%
4	30-seat Locker Rooms	69%
1	50-seat Typing Lab	64%
1	25-seat Office Machines Lab	40%
1	24-seat Dist. Ed. Lab	29%
2	30-seat Bus. Ed. Gen. Purpose Rooms	54%
1	90-seat Band Room	14%
1	90-seat Vocal Room	44%
1	30-seat Ensemble Room	36%
2	30-seat Special Education Rooms	31%

B. Based on this information, the following decisions were made:

1. Increase the size of the 400-seat Large Group Instruction to 500.

2. Delete the vocational cooking classroom and utilize the faculty dining room for that purpose.

3. Add an additional locker room facility and increase the capacity of each to 45 to handle the athletic program and the P.E. program of the middle school, which will eventually also be housed on the Pilchuck site.

4. Delete one general purpose business education room and schedule those classes into the distributive education lab.

5. Delete one special education room.

C. The question "Could better decisions be made regarding building needs when using simulation?" may be answered by comparing the results of a simulation compared to the architect's estimate. The estimates prepared by the architect are based on modification of his original interpretation of the educational specifications. The architect's estimates below were prepared in September of 1967, shortly before simulation was begun. These estimates do not exceed the 165,000 square feet, which was the maximum amount allowable at that time by the state.

Architect's Estimate			Decision Based on Simulation		
1	450-seat LGI		1	500-seat LGI	
			1	200-seat LGI	
6	Seminar Rooms	@ 24	16	Seminar Rooms	@ 15
28	Classrooms	@ 30	9	Classrooms	@ 30
2	Science Labs	@ 48	2	Science Labs	@ 64
1	Art-Painting	@ 30	1	Art-Painting	@ 30
1	Crafts	@ 30	1	Crafts	@ 30

	Architect's Estimate			Decision Based on Simulation	
1	Graphic Arts	@ 30	1	Graphic Arts	@ 30
1	Typing	@ 50	1	Typing	@ 50
2	Bus. Ed. General	@ 30	1	Bus. Ed. General	@ 30
1	Office Machines	@ 20	1	Office Machines	@ 25
1	Dist. Education	@ 24	1	Dist. Education	@ 24
1	Foods Lab	@ 24	1	Home Ec. Lab	@ 60
1	Clothing Lab	@ 24	1	Home Ec. Sem. Lab	@ 15
2	Multi Purpose	@ 24			
1	Instrumental	@ 90	1	Instrumental	@ 90
1	Vocal	@ 90	1	Vocal	@ 90
			1	Ensemble	@ 30
2	Special Educ.	@ 24	1	Special Educ.	@ 30
1	Wood-Metal Power Mech.	@ 72	1	Wood-Metal	@ 60
1	Electronics	@ 24	1	Power Mech	@ 30
			1	Electronics	@ 30
1	Drafting	@ 45	1	Drafting	@ 45
1	Vo-Ag	@ 24	1	Vo-Ag	@ 30
6	Physical Educ.	@ 45	5	Physical Educ.	@ 45
1	Instr. Matr. Center	@ 375	1	Instr. Matr. Center	@ 150
1	Library Classroom	@ 30	4	Resource Centers	@ 70
1	Language Lab	@ 45	1	List. Center	@ 45

The architect was not able to accurately estimate either seminar or classroom space. Considering special education, business education and regular classrooms, the architect over-estimated by 21 classrooms the Pilchuck needs. In addition, the large group instruction seating space needed was also underestimated.

In view of these findings, it is accurate to say that GASP simulation did aid considerably in making better decisions concerning building needs.

III. Are the economies achieved by using GASP significant?

If one interprets this question as "Were the number of square feet this program requires cut?", the answer is "No." If, however, one interprets this question as "Were inefficient spaces cut and utilized in more efficient ways?", the answer has to be "Yes."

If Pilchuck High School had been built based upon the architect's estimates, the program would have been restricted because of inadequate large group meeting space. Ten 30-seat classrooms would have been used for 15-seat seminars, and a total of eleven 30-seat stations would have sat empty the majority of the time.

The fact that these were not constructed, points to potential significant economies. If the present state matching ratio is used, the Marysville School District was saved $388,773 in inefficiently used space. However, since the square feet saved by simulation was used to increase some class seating capacities, to add another large group area, to add more teacher offices, more storage space, and more resource center area, it is not accurate to say that the district saved this amount of money. There is no question, however, that the savings made by

keeping unusable space from being constructed was beneficial to the Marysville School District. Finally, the improvement made to the Pilchuck High School program because of the simulation seems to be considerable.

ADDITIONAL SIMULATIONS

After the simulation using 1,500 students was completed, the enrollment was reduced to 850. The same procedures that had been utilized at 1,500 were again applied to the 850 enrollment. Schedules for 850 students were obtained by selecting the required number for each grade level. The technique used excluded all students whose last name began with the letters R through Z. At the end of the second run, the enrollments were compared with the original runs using 1,500 students. In only four courses the sampling method caused enrollments to deviate from the predicted enrollment by more than five students. Student schedules were modified to achieve the predicted enrollments of these four courses.

Simulation results with four classes and 850 students:

(a) Students scheduled without conflict 85%

(b) Teachers scheduled without conflict 97%

(c) Time schedule evaluation 94%

(d) Rooms and their utilization

1	400 Lg. Group	61%
6	Regular Class	75%
11	Seminar Rooms	81%
1	Phys. Sci. Lab @ 32	58%
1	Bio. Sci. Lab @ 32	72%
1	Vo-Ag Room	36%
1	Wood Lab @ 32	78%
1	Metal Lab @ 32	30%
1	Power Mech	30%
1	Elect. Lab	42%
1	Drafting Lab @ 30	52%
1	Graphic Arts Lab	54%
1	Art Lab	42%
1	Crafts Lab	30%
1	Home Ec. Lab @ 30	68%
1	Home Ec. Sem @ 15	82%
2	Locker Room @ 45	64%
1	Typing Lab @ 50	36%
1	Office Machines	24%
1	Dist. Education	28%
1	Bus. Ed. Gen. Purpose Room	76%
1	Band Room @ 90	33% (incl. LGI inst.)
1	Vocal Room @ 90	50%
1	Vocat. Ckg. Room	28%
1	Special Education Room	33%
1	Challenge Room	60%

The simulation of the Pilchuck program as a four year high school of 850 reinforced the opinion that in deciding what space to cut, serious impairment of the program of the school would result. Simulation demonstrated that a four year high school of 850 needs the same facilities as a four year high school of 1,500, and that these facilities would be used less. This simulation clearly demonstrates that it is impractical to build Pilchuck High School in the first phase as a four year high school.

Simulation results with freshman and sophomore classes of 850 students:

(a) Students scheduled without conflict 81%

This low percentage is somewhat of disappointment. If more time had been available, several more runs could have been made. This low percentage does not measurably affect room utilization percentages.

(b) Teachers scheduled without conflict 95%

(c) Time schedule evaluation 84%

(d) Rooms and their utilization

1	400 Lg. Group	45%
6	Reg. Classrooms @ 30	74%
11	Seminar Rooms @ 15	72%
1	Biology Lab @ 64	84%
1	Vo-Ag Room	13%
1	Wood-Metal Lab @ 64	48%
1	Drafting Lab @ 30	42%
1	Graphic Arts @ 30 (photography)	30%
1	Art Lab	28%
1	Crafts Lab	16%
1	Home Ec Lab @ 60	52%
1	Home Ec Sem @ 15	92%
4	P.E. Locker Rooms @ 30	58%
1	Typing Lab @ 50	30%
1	B.E. Gen. Purpose Room @ 30	32%
1	Band Room @ 90 (with LGI Sect. Assigned)	50%
1	Vocal Room @ 90	28%
1	Special Educ. Room	?
1	Challenge Room	?

The following decisions were arrived at after this simulation.

1. Cut the Vo-Ag Room.

2. Temporarily house the band and vocal rooms in one of the 95-seat areas of the large group instruction area.

3. Increase the size of the large group instruction area to 500.

Again, the simulation demonstrated the difficulty of building only a partial plant. However, it is clearly a more acceptable alternative than building a four year high school with 850 students. If Pilchuck High School should have to be constructed in anything other than consecutive phases, building design will have to be considerably altered and the program changed to some degree.

In view of these findings, we believe it is accurate to say that the GASP simulation did assist considerably in arriving at better decisions concerning building needs for Pilchuck High School.

CONCLUSIONS

The researcher feels that based on the findings of this study, the following conclusions can be drawn.

1. Simulation of an anticipated program is possible, but it entails considerable amount of time and some expertise. Nine to twelve months is recommended as minimum for simulation.

2. Simulation of an anticipated program forces those planning the school to articulate rather specifically the kind of program envisioned and enables them to ask a number of "what if" questions; the answers to which will allow them to make rather good decisions about this program.

3. Simulation in this study did not reduce the actual square feet required in the Pilchuck High School program. It did, however, make a significant contribution to the kinds of classroom spaces that will be constructed. Simulation of other programs may demonstrate that space sometimes can be deleted.

4. The costs involved in simulation are warranted in view of the additional information gained and potential savings. Simulation of all proposed secondary schools before construction would appear to be desirable.

5. At the beginning of the simulation, the main concern was with improving the building construction decisions. Even though this was accomplished, the real benefits of program simulation are discussion that must occur and decisions that must be made prior to simulation involving teachers, principals, central office staff and architects. This process forces all involved to clearly define the kind of program desired; and then as simulation proceeds, to consider the results of and alternatives to this program, space design, and room and staff utilization as they all relate to one another.

Appendix A

Course Offerings

101	Art
102	Crafts
103	Painting
110	General Business
118	Personal Typing
111	Typing I
112	Typing II
113	Shorthand I
114	Shorthand II
115	Bookkeeping
116	Distributive Education
117	Office Machines
120	English I
121	English I Sp
122	English II
123	English II Sp
124	English III
125	English III Sp
126	American Studies
127	English IV
128	Annual
129	Journalism
130	Debate
131	Drama
132	Speech I
133	Speech II
135	Humanities
140	Spanish I
141	Spanish II
142	German I
143	German II
144	German III and IV
145	French I
146	French II
147	French III and IV
150	Home Ec I
151	Family Relations/Housing
152	Adv. Foods/Adv. Clothing
153	Vocational Cooking
160	Industrial Arts Lectures
161	Beginning Woodshop
162	Advanced Woodshop
163	Photography/Graphic Arts
164	Beginning Drafting
165	Intermediate and Adv. Drafting
166	Metal Shop
167	Agriculture I and II
168	Farm Shop/Farm Management
169	Forestry/Ornamental Horticulture
170	Electricity
171	Electronics
172	Power Mechanics
180	General Math
181	Pre Algebra
182	Algebra
183	Geometry
184	Adv. Algebra and Trig
185	Math Analysis
190	Band
191	Swing Ensemble (Vocal)
192	Undergraduate Choir
193	Music Theory
194	Graduate Choir
195	Orchestra
200	Boys PE
201	Girls PE
202	Adv. PE
203	Drivers Training
210	General Science
211	Biology Sp
212	Biology
213	Physics
214	Physical Science
215	Chemistry
216	Adv. Chemistry-Biology
220	Wn. St. History/World Geography
221	U.S. History/World History
222	C.W.P./Govt.
223	Coed. Family Relations
224	Psychology
225	Sociology
226	Economics
230	Special Education
204	Health/Orientation
300	Challenge (Dropout Prevention)
400	Job Experience

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